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Effects of nonlocality in time of interactions of an atom with its surroundings on the broadening of spectral lines of atoms

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Abstract

We investigate effects of nonlocality in time of the interaction of an atom with its surroundings on the spectral line broadening. We show that these effects can be very significant: in some cases nonlocality in time of this interaction can give rise to a spectral line splitting.

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Separation of scales plays an important role in many problems of physics because it allows one to select relevant degrees of freedom and to describe a quantum system only in their terms. Integrating out other degrees of freedom results in nonlocality in time of the interaction in this system. As is well known, the dynamics of such a system is not governed by the Schrödinger equation, since this equation is local in time, and interaction Hamiltonians describe instantaneous interactions. At the same time, in Ref. [1] it has been shown that the Schrödinger equation is not the most general dynamical equation consistent with the current concepts of quantum physics, and a more general equation of motion has been derived as a consequence of the Feynman [2,3] and canonical approaches to quantum theory. Being equivalent to the Schrödinger equation in the case of instantaneous interactions, this generalized dynamical equation permits the generalization to the case where the dynamics of a quantum system is generated by a nonlocal-in-time interaction. It has been shown [1] that the generalized quantum dynamics (GQD) developed in this way may be an important tool for solving various problems in quantum theory.

An invaluable tool for computing physical quantities in the theories with disparate energy scales are effective field theories (EFTs) [4,5]. Following the pioneering work of Weinberg [6], the EFT of nuclear forces has become very popular in nuclear physics (for a review, see [7]). To describe low energy processes

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